

Arsenic

What Is It? Inorganic and organic arsenic occur naturally in the environment, with inorganic arsenic being the most abundant form. Inorganic arsenic is associated with other metals in igneous and sedimentary rocks, and it occurs in combination with many other elements, especially oxygen, chlorine, and sulfur. Organic arsenic contains carbon and hydrogen. Both inorganic and organic arsenic exist naturally in soils, plants, animals, and humans. Most pure, inorganic arsenic compounds are white or colorless powders with no smell or unique taste. Because it is an element, arsenic does not degrade nor can it be destroyed.

Symbol:	As
Atomic Number: (protons in nucleus)	33
Atomic Weight:	75

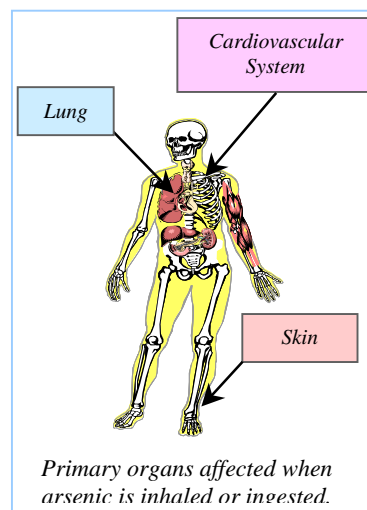
How Is It Used? Arsenic has been recognized from ancient times to be poisonous and in past centuries was used to treat syphilis. Arsenic is used primarily as an active ingredient in pesticides (although less so today than decades ago), as a wood preservative, and in metallurgical applications. It is also used in agriculture such as for antibiotics and feed additives.



What's in the Environment? Arsenic occurs everywhere in the environment. Weathering of rock is the major natural source of inorganic arsenic, and it is also released by human activities. For example, arsenic is emitted as a fine dust when arsenic-containing ores are heated at smelters to process copper or lead. The concentration of arsenic in the earth's crust ranges from 2 to 5 milligrams per kilogram (mg/kg). The median natural soil concentration is 6 mg/kg, and it ranges from 0.1 to 40 mg/kg. Water-soluble arsenites (the trivalent form, AsIII) and arsenates (the pentavalent form, AsV) are most common in the environment. Arsenic (especially arsenites) can be relatively mobile, with the typical concentration associated with soil particles estimated to be 10 to 200 times higher than in the interstitial water (water in the pore spaces between the soil particles). Bacteria, fungi, and some plants methylate inorganic arsenic, which converts it to organic arsenic. Many methylated forms of organic arsenic are volatile, such as dimethylarsine. Some organisms (notably in aquatic systems) can accumulate nontoxic, organic forms of arsenic within their bodies; for example, the concentration of arsenobetaine in shrimp is often high. However, the typical ratio of the concentration of arsenic in plants to that in soil is low, estimated at 0.006 (or 0.6%).



What Happens to It in the Body? Upon ingestion, dissolved arsenic compounds are readily absorbed (80-90%) through the gastrointestinal tract and are distributed in the blood to the liver, kidney, lung, spleen, aorta, and skin. Pentavalent arsenic is reduced to the trivalent form (which is less toxic) in the body. This form is then methylated in the liver to create the even less toxic methylarsinic acid, which facilitates excretion. Most arsenic (75-90%, depending on the compound) is eliminated within a week, especially from the liver, kidney, and spleen, while that in the skin, brain, and skeleton remains somewhat longer. When arsenic particles are inhaled as dust and deposited in the lungs, most is absorbed into the bloodstream and is distributed throughout the body as above. Arsenic in soil or dissolved in water does not readily penetrate the skin, so dermal exposures are not typically of concern.



What Are the Primary Health Effects? Depending on the amount ingested, arsenic can be beneficial or very poisonous. Several animal studies suggest that low levels of arsenic in the diet are essential, but extremely large doses can cause congestive heart failure and convulsions. However, wide recognition of its toxicity makes arsenic poisoning today very rare. Human

symptoms of arsenic poisoning include nausea, vomiting, and diarrhea. Ingesting small amounts over time produces chronic effects such as skin darkening and formation of corns, damage to peripheral nerves, cardiovascular system effects, hair and appetite loss, and mental disorders. Arsenic can also cause reproductive effects, including spontaneous abortions and reduced birth weights. Epidemiological studies indicate an association between arsenic concentrations in drinking water and increased incidences of skin, liver, bladder, respiratory, and gastrointestinal cancers. Inhaled arsenic can damage mucous membranes and cause rhinitis, pharyngitis, and laryngitis, and possibly nasal perforation. Occupational exposure studies show a correlation between arsenic exposure and lung cancer. From these sets of data, the Environmental Protection Agency (EPA) has classified inorganic arsenic as a known human carcinogen.

What Is the Risk? The EPA has developed toxicity values (see box below) to estimate the risk of getting cancer or other adverse health effects as a result of inhaling or ingesting arsenic. The toxicity value for estimating the risk of getting cancer is called a slope factor (SF), and the value for the non-cancer effect is called a reference dose (RfD). An SF is an estimate of the chance that a person exposed to the chemical will get cancer from taking in one milligram per kilogram of body weight per day (mg/kg-day) for a lifetime. An RfD is an estimate of the highest dose that can be taken in every day without causing an adverse non-cancer effect. These toxicity values have been developed based on studies of workers exposed to arsenic in occupational settings, workers applying arsenical pesticides, and populations consuming drinking water containing high concentrations of arsenic.

<i>Chemical Toxicity Values</i>		
Cancer Risk		Non-Cancer Effect
<i>Inhalation SF</i>	<i>Oral SF</i>	<i>Oral RfD</i>
15 per mg/kg-day	1.5 mg/kg-day	0.0003 mg/kg-day

To illustrate how the RfD is applied, a 150-pound (lb) person could safely ingest 0.02 mg arsenic every day without expecting any adverse effects (2.2 lbs = 1 kg, or 1,000 grams, or 1 million mg). In contrast to the RfD, which represents a “safe daily dose” (and so is compared to the amount an individual takes in, as a ratio), the SF is multiplied by the amount taken in to estimate the cancer risk. Using the SF, the EPA estimates that a person would have a one-in-a-million chance of developing cancer if exposed to air containing 0.0002 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) arsenic or to drinking water containing 0.02 $\mu\text{g}/\text{liter}$ arsenic every day over a lifetime.

What Are the Current Limits for Environmental Releases and Human Exposure? To help track facility releases to the environment, the Superfund amendments that address emergency planning and community right-to-know require certain chemical releases to air, water, or land to be reported and entered into a nationwide Toxic Release Inventory. For all arsenic compounds, the reportable quantity is one pound (454 g) for releases that are immediately reported. For drinking water, EPA has established a maximum arsenic level of 0.05 mg/liter. The Occupational Safety and Health Administration (OSHA) has established protective levels of 0.01 mg of inorganic arsenic and organic arsenic compounds per cubic meter of air (mg/m^3).

Where Can I Find More Information? More information on arsenic can be found in the primary information source for this overview: the Toxicological Profile for Arsenic prepared by the Agency for Toxic Substances and Disease Registry (ATSDR). Several sources of information are available on the Internet, including the ATSDR ToxFAQS (<http://www.atsdr.cdc.gov/toxfaqs.html>), the EPA’s Integrated Risk Information System Database (<http://www.epa.gov/iris/subst/index.html>), and the National Library of Medicine Hazardous Substances Data Bank (<http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB>).

